Environment Canada | Environnement Canada

Conservation and Protection | Conservation et protection

Environmental Protection | Protection de l'environnement

Environment CANADA Environnement
2022993I VOL 88 ISS 2 880100
EXC # 001
TD 171.5.C3 R43
REGIONAL PROGRAM REPORT (CANADA. ENVIRONMENTAL PROTECTION SERVICE. PAC 00FF

Department of Environment
Environmental Protection
Pacific Region
Yukon Branch
[Whitehorse, YT]

WATER QUALITY AND BIOLOGICAL SURVEY OF STREAM AND LAKE HABITATS IN THE VICINITY OF KING POINT, YUKON -BEAUFORT SEA COAST

REGIONAL PROGRAM REPORT NO. 88-02

D. Davidge and G. Mackenzie-Grieve

January, 1988

ABSTRACT

A baseline inventory survey of water chemistry, sediment and biological conditions was conducted by Environmental Protection, Environment Canada staff at several stream and lake locations near King Point, along Yukon's Beaufort Sea coastline, in August of 1985. This investigation was conducted to provide additional information on freshwater habitats in the vicinity of proposed major developments in support of the Beaufort Sea offshore oil and gas exploration and development.

Stream and lake water quality were generally of a pristine nature with most chemical parameters present being well below the recommended criteria for drinking water. The exceptions were elevated Fe and Hg detected in some stream and lake samples. Nutrient levels found in the lakes surveyed indicated they were characteristic of ultra-oligotrphic conditions.

Benthic invertebrate populations surveyed in stream habitats showed low similarity between locations sampled as well as varied densities and composition. Lake populations were not comparable due to different sampling methods, however, the results obtained provide some representation of benthic invertebrates present in coastal tundra lakes.

RESUME

Le personnel de la Protection de l'environnement, d'Environnement Canada, a effectué en août 1985 une évaluation de base des conditions chimiques, sédimentaires et biologigues de l'eau en plusieurs points de cours d'eau et de lacs près de King Point, le long du littoral de la mer de Beaufort au Yukon. Ces recherches ont été effectuées pour obtenir de l'information supplémentaire sur les habitats d'eau douce au voisinage d'importantes zones d'aménagement, proposées en vue des activités d'exploration et d'exploitation pétrolières et gazeuses au large de la mer de Beaufort.

La qualité de l'eau des rivières et des lacs était généralement celle d'une nature vierge, la plupart des paramètres chimiques pour l'endroit étant bien inférieurs aux normes proposées pour l'eau potable. Seules exceptions, les concentrations élevées de Fe et de Hg décelées dans certains échantillons de cours d'eau et de lacs. La teneur en agents nutritifs des lacs analysés révélait des conditions ultra-oligotrophes.

L'étude des populations d'invertébrés benthiques présentes dans les habitats des cours d'eau, a révélé une faible similitude entre les endroits échantillonnés, ainsi que diverses densités et compositions. Les populations lacustres ne pouvaient se prêter à une étude comparative en raison des différentes méthodes d'échantillonnage; cependant, les résultats obtenus donnent une certaine représentation des populations d'invertébrés benthiques présentes dans les lacs de la toundra côtière.

TABLE OF CONTENTS

		Page
ABSTRACT		i
RESUME		ii
TABLE OF CONTENTS		iii
	List of Figures	v
	List of Tables	vi
1	INTRODUCTION	1
2	STUDY AREA	3
3	METHODS	6
3.1	Water Quality and Quantity	6
3.2	Sediments	8
3.3	Laboratory Quality Control	9
3.4	Benthic Fauna	9
4	RESULTS AND DISCUSSION	11
4.1	Water Quality and Quantity	11
4.1.1	Stream Water Quality	11
4.1.2	Lakes Water Quality	13
4.2	Sediments	15
4.2.1	Stream Sediments	15
4.2.2	Lake Sediments	16
4.3	Bottom Fauna	17
4.3.1	Stream Bottom Fauna	17
4.3.2	Lakes Bottom Fauna	21
REFERENCES		22
ACKNOWLEDGEMENTS		23

TABLE OF CONTENTS (continued)

		Page
APPENDICES		24
APPENDIX I	WATER AND SEDIMENT SAMPLE COLLECTION, PRESERVATION ANALYTICAL TECHNIQUES	25
APPENDIX II	STREAM AND LAKE WATER QUALITY	38
APPENDIX III	STREAM AND LAKE SEDIMENTS	48
APPENDIX IV	STREAM AND LAKE BOTTOM FAUNA	58

LIST OF FIGURES

Figure		Page
1	LOCATION OF STUDY AREA	2
2	LOCATION OF SAMPLE STATIONS	4
3	DISTRIBUTION OF MAJOR STREAM INVERTEBRATES GROUPS	18

LIST OF TABLES

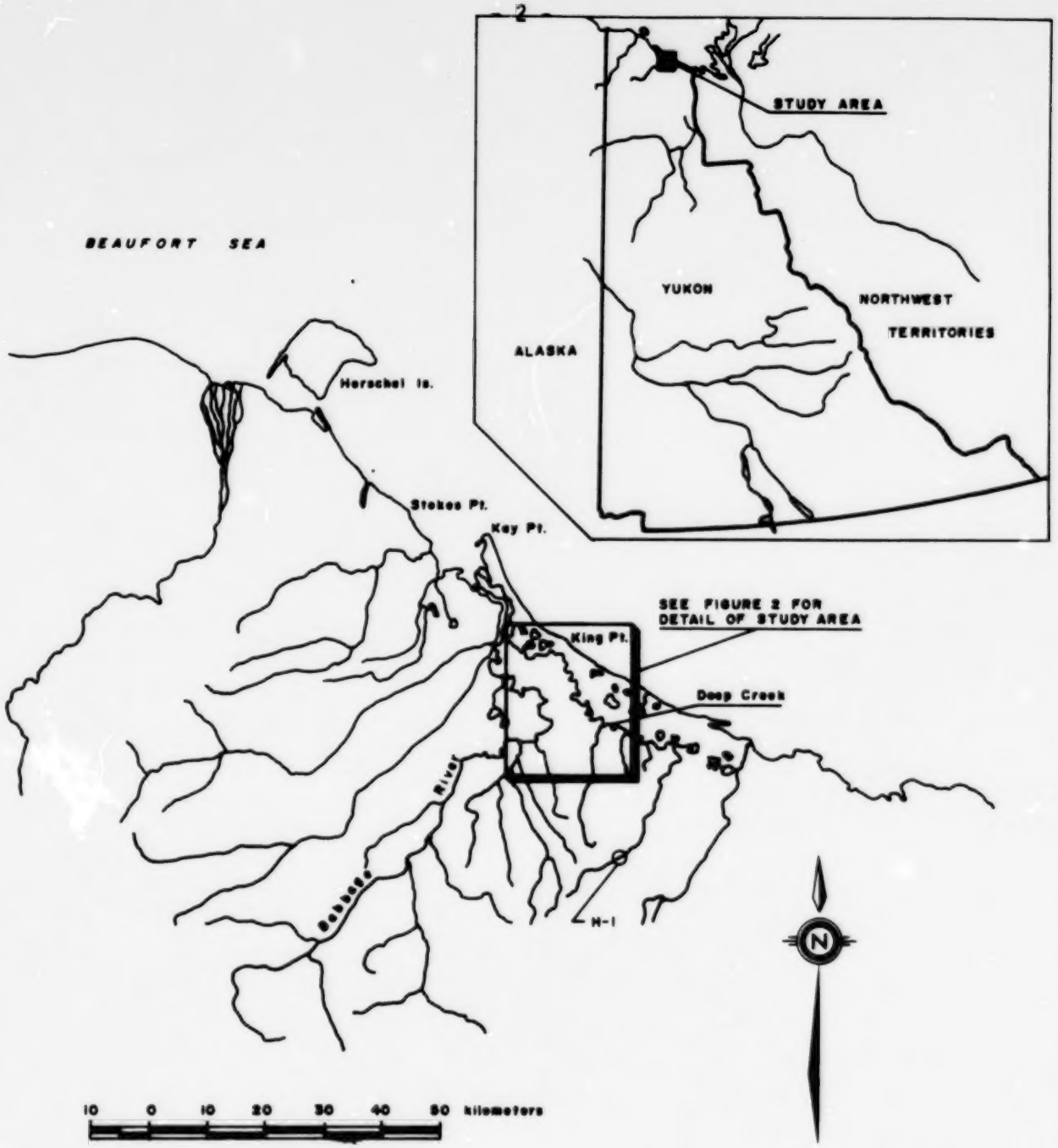
Table		Page
1	PERCENT SIMILARITY INDEX (PSC) FOR STREAM STATIONS	20

1 INTRODUCTION

Since 1982, Environmental Protection has conducted four baseline inventories of marine, lagoon and freshwater habitats in the vicinity of King Point and Stokes Point along Yukon's north coast. These investigations were carried out in response to proposals made by private industry to develop ports and shore based facilities at these two sites in support of oil and gas exploration in the Beaufort Sea.

This survey is an addition to the previous investigations and was carried out to identify physical and biological characteristics of freshwater habitats in the vicinity of King Point where an inland rock quarry, haul road and a shore and port facility have been proposed. Refer to Figure 1 for study area location.

Between July 30 and August 5, 1985, Environmental Protection field staff conducted a baseline inventory of water quality, sediments and benthic invertebrates at selected stream locations and three tundra lakes west of King Point.



Historical Sampling Locations

H-1: Station 9, Allen and MacKenzie-Grieve (1984)

FIGURE 1 LOCATION OF STUDY AREA

2 STUDY AREA

The study area falls within the boundaries of a development proposal originally submitted by Peter Kiewit and Sons Company Limited to the Northern Affairs Program in 1983. The proposal included a quarry located approximately 17 kilometers south of King Point along rock bluffs on the northeastern limits of the British Mountains. An all weather haul road was planned for transporting the quarried material to a port facility at King Point. A camp, fuel storage facility and airstrip were proposed immediately south of the King Point lagoon. See Figure 2 for location of the proposed development area. This proposal is currently inactive and has been withdrawn by the proponent.

A second proposal for a multi-user port facility was made in 1985 by Monenco Engineering Ltd. This proposal remains active and is presently undergoing environmental screening and review.

The study area drains primarily into Deep Creek, a coastal drainage basin adjacent to the Babbage River system. The exception is surface runoff from coastal slope areas which drains into the Beaufort Sea.

A total of 14 sampling stations were selected in the study area, as shown in Figure 2. Station 1 is located approximately 18 kilometers inland on an unnamed tributary of Deep Creek which drains the proposed rock quarry area. Station 2 is located on Deep Creek approximately 5 kilometers upstream of the confluence of the unnamed tributary on which Station 1 is situated. Station 3 is located on Deep Creek downstream of the unnamed tributary near a potential borrow pit area. Stations 4 and 5 are located approximately 4 and 10 kilometers, respectively, west of the King Point lagoon on Deep Creek.

Stations 6 through 14 are located on three unnamed lakes within a 3 kilometer radius west of the King Point lagoon. The lakes will be referred to as A, B and C as shown on Figure 2. Stations 6, 7 and 8 are located on Lake A, Stations 9, 10 and 11 are located on Lake B and Stations 12, 13 and 14 are located on Lake C. Lake B drains into

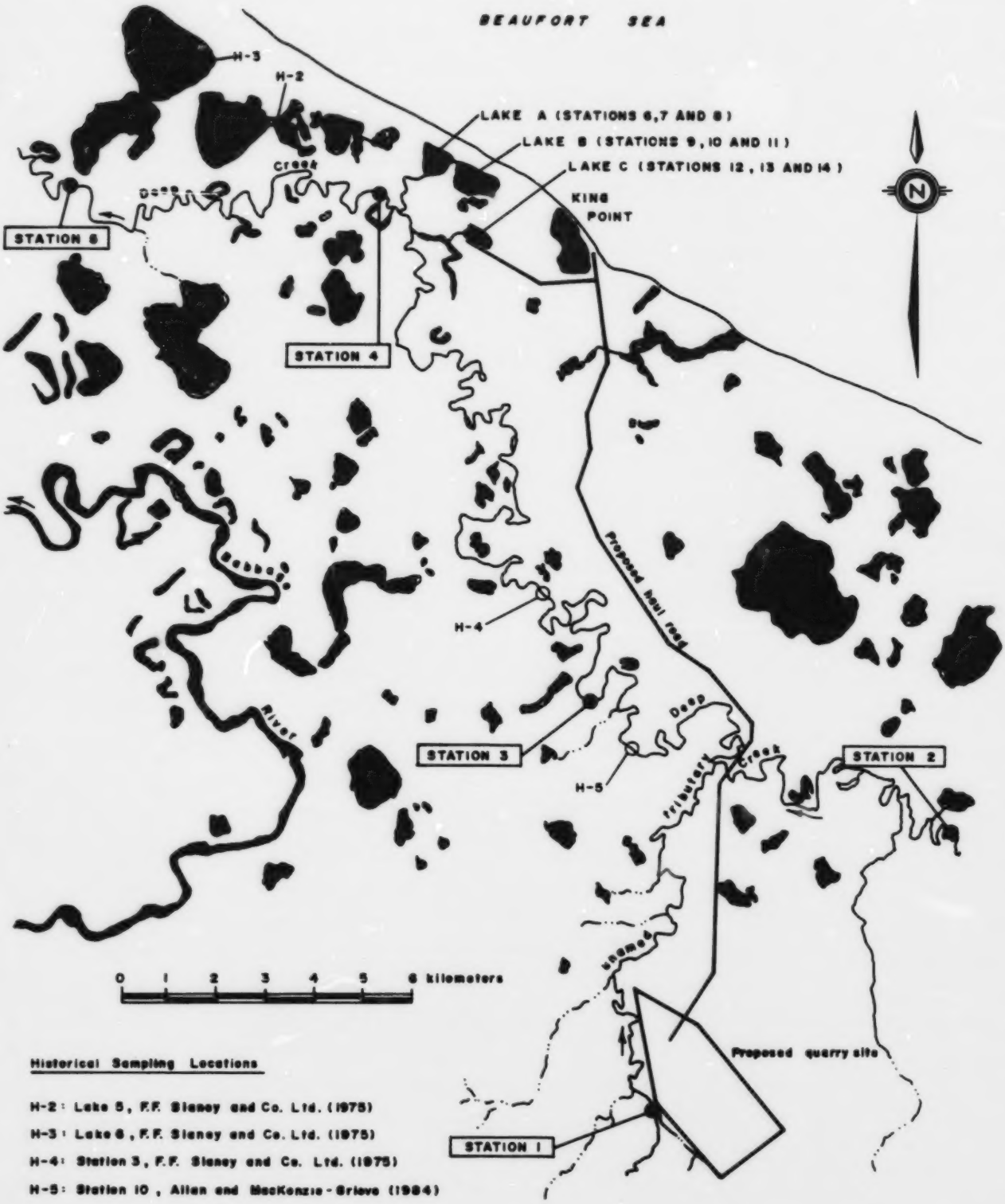


FIGURE 2 LOCATION OF SAMPLE STATIONS

Lake A which in turn drains into Deep Creek. Lake C was identified by Peter Kiewit and Sons Company Limited as a potential freshwater source. It also drains into Deep Creek. The sample stations were located on a transect close to the middle of the lake or where the water depth was greatest.

The location of sample stations identified in previous surveys are shown in Figure 1 and Figure 2 as Historical Sampling Locations.

3 METHODS

Field sampling was conducted between August 1 and 3, 1985. The exact sample date for each station is noted in Appendix II, Tables 1 and 2.

A helicopter was used to access all stream stations from a base camp established near the King Point lagoon and to air lift equipment to and from the lakes investigated. An inflatable rubber boat was used to access the lake stations.

3.1 Water Quality and Quantity

Collection, preservation and analysis methods for water samples are described in Appendix I, Table 1.
Physical water parameters measured at each stream station included temperature, conductivity, pH, dissolved oxygen and stream flow. The type of instrumentation and methods used are described in Appendix I, Table 1.

Stream flows were measured at Stations 3, 4 and 5 on Deep Creek. Flow could not be measured at Station 1 and 2 because the stream velocities encountered were below the minimum velocity which could be measured by the instrumentation used.

Physical parameters measured at each lake station include those mentioned above except flow. Measurements were also observed at depth to determine if there was stratification in temperature, pH, dissolved oxygen or conductivity in the water column. Water depth was measured using a Fish Ray electronic depth sounder.

Water samples were collected for the following nutrient and total metals analysis:

Nutrients	Total Metals
pH	Silver (Ag)
conductivity	Arsenic (As)
color	Boron (B)
total alkalinity	Barium (Ba)
total hardness	Beryllium (Be)
sulfate	Calcium (Ca)
chloride	Cadmium (Cd)
total phosphate	Cobalt (Co)
nitrite	Chromium (Cr)
nitrate	Copper (Cu)
ammonia	Iron (Fe)
total dissolved nitrogen	Mercury (Hg)
filterable residue	Magnesium (Mg)
non-filterable residue	Mangenese (Mn)
	Molybdenum (Mo)
	Sodium (Na)
	Nickel (Ni)
	Phosphorus (P)
	Lead (Pb)
	Antimony (Sb)
	Selenium (Se)
	Silicon (Si)
	Tin (Sn)
	Strontium (Sr)
	Titanium (Ti)
	Vanadium (V)
	Zinc (Zn)

A two litre polyethylene container was used to collect water samples for nutrient analysis and a 100 ml polyethylene container was used to collect water samples for total metals analysis.

One nutrient and one metals sample were collected at each of the stream stations except Station 1 where the samples were collected in triplicate to characterize the variability in water constituents. One nutrient and one metals sample of surface waters were collected at each of the lake stations. An additional set of water samples were collected at stations where stratification was observed in any of the physical water parameters. These samples were collected below the depth where the change was detected.

All water analyses for chemical parameters were carried out at the Environmental Protection Service Laboratory in West Vancouver, B.C.

3.2 Sediments

Stream sediment samples were collected at each station in triplicate for particle size and leachable metals analysis and in triplicate for hydrocarbon analysis. The Wentworth Classification System was used to describe the sediment particle size. Sample collection, preservation and analytical methods are described in Appendix I, Table 1.

Two sample methods were used in collecting sediment samples at stream stations. If stream velocity was great enough to wash fine sediment material from the sample during collection with an aluminum scoop a stainless steel corer device was used as described in Appendix I.

Lake sediments were collected using an Ekman Dredge. Some difficulty in collecting representative samples was encountered due to the thick matting of algae (Divison Chlorophyta, Family Characcae) present on the lake bottom. Because of this, sample collection took place in 0 and 2 meters water depth near shore where lake sediments were exposed.

Representative lake bottom samples from Lake C could not be collected due to mechanical failure of Ekman dredge. The data presented for Lake C represent shoreline sediments.

Sediment samples for particle size and leachable metals analysis were placed in geochemical paper sample bags, packaged in plastic bags and then frozen within 24 hours of collection using a freezing unit set up at the base camp. Those samples collected for hydrocarbon analysis were placed in heat treated 350 ml glass jars and maintained at a cool temperature.

All sediment sample analysis was conducted at the Environmental Protection Service Laboratory in West Vancouver, British Columbia.

3.3 Laboratory Quality Control

Systematic error and sample contamination during water and sediment analysis at the Environmental Protection Service Laboratory are minimized through duplicate analysis, procedural blanks and the use of standard reference materials. Internal lab quality control is carried out in all analyses before results are released to the submitter.

3.4 Benthic Fauna

Benthic invertebrates at stream stations were collected using a Surber Sampler (0.093 m2) with a mesh opening of 0.363mm. Three samples were collected at each station and placed in a 1 litre plastic container then preserved with a 10% formalin solution. Rose Bengal was added to the preservative so that invertebrates could be easily identified during sorting. A representative sample could not be collected with the Surber sampler at Station 2 because of the reduced water flow.

Lake invertebrates were collected using an Ekman Dredge @0.023m^2). As pointed out earlier the dredge could not penetrate the thick layer of vegetation present on the lake bottom so the samples obtained were not representative. Most grab attempts with the dredge resulted in bringing up huge "mops" of algae (Divison Chlorophyta, Family Characeae) of which as much as possible was placed into 8 litre plastic containers. It is suspected that an undetermined number of invertebrates were lost during retrieval of the sample. The samples were preserved in the same manner as those collected from the stream stations.

All invertebrate samples were later sorted from debris, vegetation and sediment then preserved in 70% methenol. Dr. Charles Low, a consulting biologist from Naniamo, British Columbia, identified and enumerated the invertebrates. Data from the benthic invertebrate sampling is present in Appendix IV, Tables 1, 2 and 3. Identifications shown in brackets are tentative.

4 RESULTS AND DISCUSSION

4.1 Water Quality

Water chemistry data for stream and lake stations are shown in Appendix II, Tables 1 and 2. Comparisons will be made between the data from the current study and data from previous investigations as well as with criteria recommended for drinking water and the protection of aquatic life as described in Appendix I, Table 3.

4.1.1 Stream Water Quality. Physical parameters measured in situ show little variation between stream stations in the present study. The lowest temperature recorded was 10°C at Station 1. All other stations ranged from 12 to 14°C. Previous investigations have shown that temperature can vary considerably in headwaters of Deep Creek at similar locations. Craig and McCart (1974) reported a temperature of 8.5°C on August 17, 1973 while Allan and Mackenzie-Grieve (1984) reported 12.5°C on August 6, 1983. F.F. Slaney and Company Ltd. (1975) also reported stream temperatures near Station 3 within the range found by the present survey.

The present study found in situ pH and conductivity similar at all stations, with pH ranging from 7.75 to 7.90 and conductivity ranging from 50 to 82 umhos/cm.

Percent dissolved oxygen saturation was near or exceeded 100% at the stations sampled which is characteristic of natural mountain streams. Similar % D.O. was reported by F.F. Slaney and Company Ltd. (1975).

Mean total alkalinity and total hardness were slightly higher at Station 1 than at the Stations 2 through 5 but overall the streams surveyed are characteristic of tundra streams (Craig and McCart, 1974 and Allan and Mackenzie-Grieve, 1984). Both parameters were well below the criteria recommended for drinking water. (Health and Welfare Canada, 1978).

Station 1 showed lower levels of chloride, total phosphates and ammonia but higher levels of sulfate and nitrate as compared with Stations 2 through 5 on Deep Creek. Allan and Mackenzie-Grieve (1984) reported similar characteristics between the headwaters of Deep Creek and a location close to Station 3 of the present study. Levels found for each parameter above were well below the criteria recommended for drinking water (Health and Welfare Canada, 1978). Nitrite was below the detection limit at each of the stations sampled.

Nonfilterable residues in the present study were generally low ranging from <5 to 9 mg/L. Filterable residues ranged from 55 to 86 mg/L.

The following metals were found to be below detection limits as described in Appendix II, Table 1 in all stream samples: silver (Ag), arsenic (As), beryllium (Be), cadmium (Cd), cobalt (Co), chromium (Cr), molybdenum (Mo), nickel (Ni), phosphorous (P), antimony (Sb), selenium (Se) and vanadium (V).

The metals detected were generally below the criteria recommended for drinking water and the protection of aquatic life, except iron and mercury.

Iron levels, ranging from 0.368 to 0.650 mg/L, exceeded the 0.3 mg/L criteria for drinking water (Health and Welfare Canada, 1978) at Stations 2 through 5 on Deep Creek. Levels at Station 1 averaged 0.111 mg/L. Allan and Mackenzie-Grieve (1984) reported similar findings ranging from 0.947 mg/L near Station 3 to 0.174 mg/L in Deep Creek headwaters. All levels found in the present study were well below the 1.0 mg/L critria recommended for aquatic life (Thurston, et al, 1979).

Levels of mercury ranging from 0.00007 to 0.00036 mg/L were detected at all stream stations during the present study. These levels exceed the criteria of 0.00005 mg/L recommended for the protection of aquatic life (Inland Waters Directorate, 1979, 1980). The reasons for the presence of mercury in the study area is unclear but may be characteristic of the local geology. Previous surveys in the area did not report mercury in water. (Allan and Mackenzie-Grieve 1984, Craig and McCart, 1974).

The methods used in this study did not include preserving water samples specifically for mercury analysis as recommended (Environmental Protection Service Environmental Laboratory manual, 1979). As a result mercury may be lost through absorption by the walls of the sample container and/or volatilization and therefore the levels detected may be less than the true value.

4.1.2 Lake Water Quality. All three lakes investigated are within a 3 kilometer radius west of King Point at approximately 45 meters above sea level. Lake surface area was estimated at 0.31 km^2 for Lake A, 0.45 km^2 for Lake B and 0.18 km^2 for Lake C. A maximum depth of 13.5 meters was measured in Lake C. Maximum depths found in Lakes A and B were 10.8 and 5.8 meters, respectively.

Water temperatures were similar in the three lakes studied. Lakes A and B were 11.0°C throughout the water column while Lake C showed a slight drop in temperature from 10.8°C to 10.0°C between surface and near bottom where water depth was greatest.

In situ pH was slightly higher in Lake A, averaging 8.04, than in Lakes B and C where it averaged 7.85 and 7.84, respectively. There were no changes detected in pH between surface and near bottom at any of the lakes.

In situ conductivity measurements showed some variation among the three lakes. Lake A averaged 360 umhos/cm while Lake B averaged only 65 umhos/cm. No changes in the water column were detected. Conductivity measured in Lake B in 1984 ranged from 50 to 58 umhos/cm at the surface (Davidge and Mackenzie-Grieve, 1986). In Lake C, in situ conductivity ranged from an average of 108 umhos/cm at the surface to 120 umhos/cm at 13.5 meters depth.

Percent dissolved oxygen saturation was high in all three lakes ranging from 96% to 104%. No changes were detected in the water column.

Nutrient levels found in the present study differed slightly among the three lakes sampled. Lake C was generally higher in total alkalinity, total hardness and sulfate than Lakes A and B. Chlorides, phosphates and ammonia were found in similar conentrations between the three lakes. Nitrates and nitrites were below detection limits except in one water sample from Lake A where 0.007 mg/L nitrates were detected. Nutrient levels in Lake B were similar to the previous summer (Davidge and Mackenzie-Grieve 1986), except that phosphate was slightly higher. A lake investigated near Stokes Point in 1982 was slightly higher in color, phosphates and ammonia but much lower in total alkalinity, total hardness and chlorides than that found by the present study (Allan and Mackenzie-Grieve, 1983). Water chemistry for the two lakes mentioned above are shown for comparison in conjunction with the results of the present study in Appendix II, Table 1.

Organic nitrogen was determined from the difference between total dissolved nitrogen and the sum of nitrate, nitrite and ammonia. Although it is the most abundant form of nitrogen present, much of it is resistant to rapid bacterial degradation and so is not readily available. The levels found by the present study are characteristic of ultra-oligotrophic or low productivity lakes (Wetzel, 1975).

Filterable residues ranged from 54 to 91 mg/L overall in the present study with Lake C showing the highest levels. Nonfilterable residues were low, ranging from <5 to 7 mg/L overall.

Total metals concentrations were generally below detection limits and below criteria recommended for drinking water and aquatic life although a few exceptions are noted. Aluminum was below the 0.05 mg/L detection limit in most samples collected except for 3 samples from Lake C. The levels detected were 0.05, 0.08 and 0.25 mg/L of which the later sample exceeded the 0.1 mg/L criteria recommended for the protection of aquatic life (Ontario Mnistry of the Environment, 1978). The same sample also exceeded drinking water criteria recommended for iron (0.3 mg/L) and manganese (0.05 mg/L)(Health and Welfare Canada, 1978). Lead equaled the 0.005 mg/L criteria

recommended for the protection of aquatic life (Inland Waters Directorate, 1979, 1980) in one sample from Lake B, all other samples ranged from <0.001 to 0.004 mg/L.

Mercury consistently exceeded the 0.00005 mg/L criteria recommended for the protection of aquatic life (Inland Waters Directorate, 1979, 1980) in each of the lakes sampled in the present study. Levels ranged from 0.00010 to 0.00054 mg/L in most samples except one surface sample collected in Lake C contained 0.00180 mg/L. There is insufficient information available to suggest the levels detected in the present survey are characteristic of lakes along Yukon's north slope but a previous investigation of a lake near Stokes Point reported mercury less than the 0.00020 mg/L detection limit (Allan and Mackenzie-Grieve, 1983).

4.2 Sediments

Sediment particle size, oils and greases and leachable metals analysis results are presented in Appendix III, Tables 1 through 4. For the purposes of this section results for stream and lake sediments are discussed separately.

4.2.1 Stream Sediments. Stream sediment samples collected were composed primarily of gravel material greater than 2.0 cm in size. Percentage composition of gravel ranged from 35% at Station 2 to 81% at Station 3. Size fractions in the range of less than 2.0 cm never exceed 14% with the exception of Station 2 where the medium sand range (0.25 - 0.50 cm) represented between 27% and 50% in the three samples collected. Allan and Mackenzie-Grieve (1984) reported significant amounts of the medium sand ranging from 19% to 46% composition in samples collected from Deep Creek near where Station 3 of the present study is located.

Oils and grease analysis results were all less than the 100 mg/Kg detection limit in stream sediment samples collected in the present study.

Leachable metals analysis results show no elevated levels in stream sediments. In comparison with results reportd by Allan and Mackenzie-Grieve (1984), slight changes were noted in a number of metals at a location near Station 3. Arsenic and cadmium were below detection limits (8 mg/Kg and 3 mg/Kg, respectively) in the present study while in the previous study both metals were detected in low concentrations. Silica and titanium were also found to be of lower concentration in the present study, averaging 433 mg/Kg and 7.8 mg/Kg, respectively. In comparison Silica and titanium averaged 1973 mg/Kg and 89.6 mg/Kg in the previous study. Lead, averaging 14 mg/Kg in the present study at Station 3, was the only metal to show an increase over the 4 mg/Kg average reported by Allan and Mackenzie-Grieve (1984). The slight differences detected between sediment metals found at Station 3 and that reported earlier is probably due to variations in stream characteristics such as stream velocity.

No significant changes in sediment metals between stations of the present study were noted, except that the mean values at Station 1 were, in most cases, lower than the combined mean for Stations 2 through 5.

Although not shown in Appendix III, the results for hydrocarbon analysis for stream sediment samples were negative.

4.2.2 Lake Sediments. In Lakes A and B sediment samples collected were composed primarily of medium sand (0.25 - 0.5 mm), fine sand (0.125 - 0.25 mm), very fine sand (0.063 - .125 mm) and silt/clay fractions ((0.063 mm). Percentage of sediments in the coarse sand and gravel size ranges never exceeded 3.3%. Samples collected from Lake C were collected along the shoreline and, therefore, are not representative of lake bottom sediments. The shoreline sediments are composed primarily of fine gravel and coarse sand with little or no fine sand or silt/clay fractions present. Oils and grease analysis

results of lake sediment samples ranged from 500 to 700 mg/Kg in Lake A and from 0 to 500 mg/Kg in Lake B. Oils and grease in Lake C shoreline sediments were less than the 100 mg/Kg detection limit. Leachable metals in lake sediments samples are comparable between Lakes A and B with the exception of iron, manganese and titanium. All three metals were significantly higher in Lake B than in Lake A. Lake B also shows a significant variation between the three samples collected. Sample number 19 appears to have higher concentrations of many metals including aluminum, barium, iron, manganese, phosphorous and zinc.

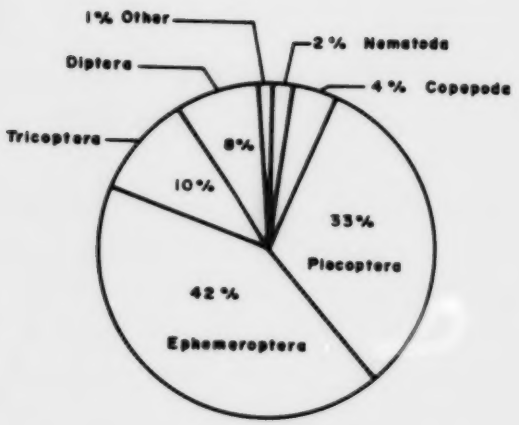
At Lake C leachable metals in shoreline sediments were not unlike those found in Lake B but in most cases values were slightly higher. Although not shown in Appendix III, results of hydrocarbon analysis of lake sediment samples were all negative.

4.3 Bottom Fauna

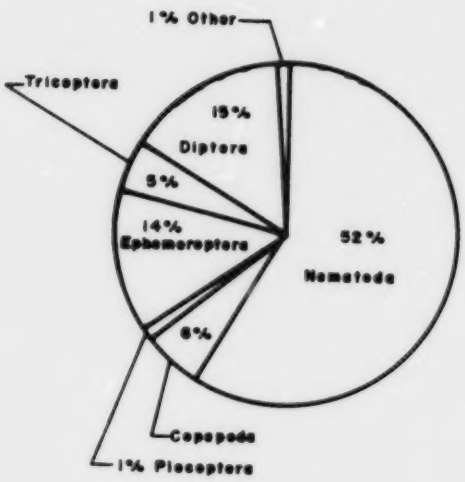
Invertebrate taxonomy and distribution are presented in Appendix IV, Tables 1 through 3. Stream and lake invertebrate data are discussed separately. Duplicate samples collected at each station were combined into one composite sample.

4.3.1 Stream Bottom Fauna. In the present study a total of 40 taxa were identified in the stream invertebrate samples collected from 5 stations. Of these, 28 taxa were identified to the genus or species level. Figure 3 shows the diversity of invertebrates at each station according to major taxanomic groups.

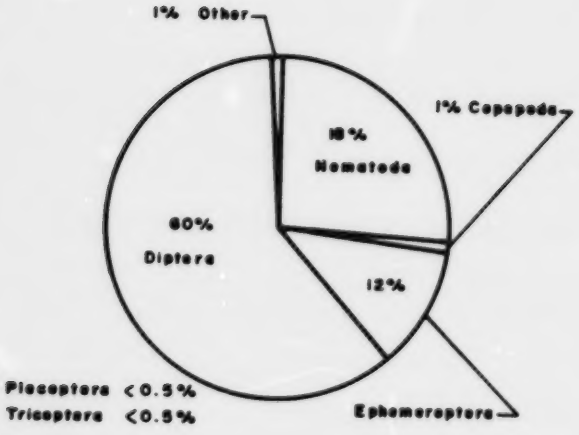
At Station 1, 20 taxa were identified, of which 15 were to the genus or species level. The density was calculated at 974 individuals/m^2. The most abundant organism was Podmosta sp. (32%) of the Order Plecoptera. From the Order Ephemeroptera two genera were identified in significant numbers, Baetis(hudsonicus (24%) and Cinygmula sp. (17%). The former, tentatively identified, is possibly



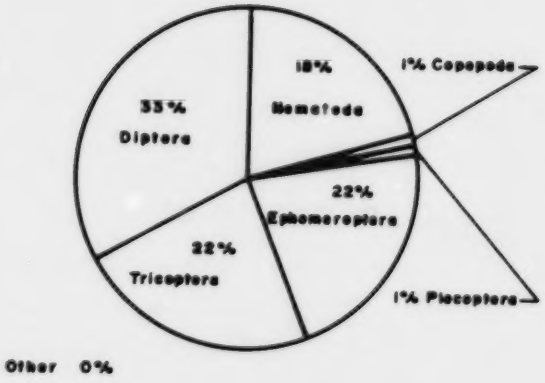
STATION 1



STATION 3



STATION 4



STATION 6

FIGURE 3 DISTRIBUTION OF MAJOR STREAM INVERTEBRATE GROUPS

an undescribed species (Dr. C. Low, personal comm., Sept. 31, 1985). A Trichopteran, Brachycentrus sp., represented about 10% of the sample. Other groups represented in low numbers include Hydrozoa, and Collembola. In comparison, bottom fauna data reported by Allan and Mackenzie-Grieve (1984) indicated a genus from the Order Amphipoda, Synurella sp., represented 64% of the sample collected in headwaters of Deep Creek. Synurella sp. was identified as a new species by E. C. Bousfield (Allan and Mackenzie-Grieve, 1984) and as being the first record of this genus in Canada. The present study did not find this genus at Station 1 or at any of the other stream stations. Other taxa identified in the head waters of Deep Creek by the previous study included Podmosta sp. (9%) and Cinygmula sp. (10%).

Station 3 of the present study reflected the most diverse population and largest numbers of individuals per station. A total of 31 taxa were identified, 20 to the genus or species level. The density was calculated at 2456 individuals/m^2. The most abundant taxa represented was the Phylum Nematoda (52%). Other taxa in significant numbers included two genera from the Order Emphemeroptera, Baetis sp. (10%) and Cinygmula sp. (4%), one genus from the Order Trichoptera, Brachycentrus sp. (5%) and nine genera from the Order Diptera, representing 15% of the sample. The most abundant Diptera genus was Micropsectra sp. (7%).

At Station 4, 24 taxa were identified of which 18 were to the genus or species level. The density was calculated at 1967 individuals/m^2. The most abundant invertebrate was Micropsectra sp. (44%) of the Order Diptera. Five other Dipteran genera were identified, representing an additional 16% of the sample. Other invertebrates in significant numbers included Nematoda (18%), Tubifex sp. (2%) and Baetis sp. (10%).

At Station 5, the present study found 19 different taxa of which 15 were identified to the genus or species level. Abundance was more widely dispersed between 5 major taxonomic groups. They include Nematoda (18%), an Ephemeropteran genus, Cinygmula sp. (11%), a Trichopteran genus, Brachycentrus sp. (22%) and a Dipteran genus, Micropsectra sp. (17%).

To evaluate the similarity of two stream stations the following index as described by Brock (1977) was used:

$$\text{Percent Similarity (Psc)} = 100 - 0.5 \sum_{i=1}^{k} (a_i - b_i)$$

where a_i and b_i are, for a given species, percentages of the total samples A and B which that species represents. The absolute value of their difference is summed over all species, K. Results of the Psc calculations are summarized in Table 1.

Table 1 Percent Similarity Index (Psc) for Stream Stations

Station	3	4	5
1	55	19	31
3		47	59
4			46

Psc in stream invertebrate populations were relatively low. Similarity between Station 1 and Stations 3, 4 and 5 ranged from 19 to 55%. Stations 3 and 5 showed the most similarity (59%) while Station 4 was equally similar to Stations 3 and 5 (47% and 46% respectively).

4.3.2. Lake Bottom Fauna. Results of invertebrate sampling on the lakes investigated by the present study do not represent a quantitative measure of invertebrate abundance due to the methods used and the type of lake bottom encountered. Even though the results are inconsistent, they do provide a qualitative measure of benthic invertebrates present in tundra lakes on Yukon's north slope.

Appendix IV, Table 3 presents data from the composite of three grabs samples collected in Lake A and Lake B. Due to problems with the mechanical operation of the dredge no benthic invertebrate samples were collected from Lake C.

A total of 30 different taxa were identified in samples from Lake A and Lake B, of which 21 were to the genus or species level. Lake A invertebrate samples were dominated by the Order Diptera (62%). The most abundant genera of this order were Micropsectra sp. (44%) and Stenochironomus sp. (14%). A species of the Order Gastropoda (Phylum Mollusca), Valvata sincera was also abundant (24%).

Invertebrate abundance in samples from Lake B were more evenly distributed among three major groups. These included the Class Oligochaeta (36%), the Order Diptera (30%) and the Phylum Mollusca (24%). The most abundant organism, Tubifex sp., was the only Oligochaeta present. The Order Diptera was represented by 6 genera representing between 1% and 9% of the sample. The molluscs identified represented between 1% and 11% of the sample.

REFERENCES

Allan, R.B., and G.R. Mackenzie-Grieve, Water Quality and Biological Survey of Stokes Point and King Point, Yukon-Beaufort Sea Coast. Environmental Protection Service, Yukon Branch, Regional Program Report No. 83-23, 1983.

Allan, R.B. and G.R. Mackenzie-Grieve, Water Quality and Biological Survey of Five Streams in Vicinity of Stokes Point, Yukon-Beaufort Sea Coast. Environmental Protection Service, Yukon Branch, Regional Program Report No. 84-19 , 1984.

Brock, D. A., Comparison of Community Similarity Indexes. Journal, Water Pollution Control Federation, 49(2): 2488-2494, 1977.

Craig, P.C. and P.J. McCart, Classification of Stream Types in Beaufort Sea Drainages Between Prudhoe Bay, Alaska and the Mackenzie Delta. Canadian Arctic Gas Study Ltd., Biological Report Series 17 (1974).

Davidge, D.A. and G.R. Mackenzie-Grieve, A Follow-up Water Quality and Biological Survey of King Point and Stokes Point, Yukon-Beaufort Sea Coast. Environmental Protection Service, Yukon Branch, in press, 1986.

F.F. Slaney and Company Limited, Environmental Overview of the King Point Area, Yukon Territory For Imperial Oil Limited Calgary, Alberta 1975.

Health and Welfare Canada, Guidelines for Canadian Drinking Water Quality 1978, Supply and Services Canada, 1979.

Inland Waters Directorate, Guidelines for Surface Water Quality. Vol. 1, Inorganic Chemical Substances, Environment Canada, Ottawa, 1979, 1980.

Low, Dr. C., personal communication, Sept. 31, 1985.

Ontario Ministry of the Environment, Water Management--Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment. 1978.

Peter Kiewit and Sons Ltd., Kiewit Project: Arctic Quarry Initial Environmental Evaluation.

Smith, G.M., The Fresh-water Algae of the United States. Second Edition, McGraw-Hill Book Co. Inc. 215p. 1950.

Thurston, R.V., et al, A review of EPA Red Book: Quality Criteria for Water. Water Quality Section, American Fisheries Society, Bethesda, MD, 313p. 1979.

Wetzel, R.G., Limnology. Saunders College Publishing, Philadelphia, PE, 743p. 1975.

ACKNOWLEDGEMENT

The authors acknowledge the partial funding for this study made available through the Environment Canada, Pacific and Yukon Region, Baseline Studies Fund. Logistical field support was provided by the Polar Continental Shelf Project of the Department of Energy, Mines and Resources.

The authors would like to thank Mr. J. Cornell for his valuable assistance in the field, L. Macara for manuscript preparations and B.W. Kelso for his technical review of this paper.

APPENDICES

APPENDIX I

WATER AND SEDIMENT SAMPLE

COLLECTION, PRESERVATION, ANALYTICAL TECHNIQUES

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Temperature	0.1°C	In situ temperature reading.	YSI Model 33 Conductivity, Temperature, Salinity Meter	
Flow		In situ flow measurements using a Marsh-McBirney Electromagnetic Flow meter.	Cross-section of stream was measured and the velocity of flow was calculated using the standard Price-type Current Meter Method [3].	
Dissolved Oxygen	1.00 mg/L	In situ measurement. The instrument was calibrated in the field using the air saturation method as described in the YSI Model 57 Dissolved Oxygen Meter Manual.	YSI Model 57 Dissolved Oxygen Meter	
pH		Small aliquots of sample were taken and read soon after collection. No preservative. Instrument was calibrated using 7.0 buffering solution.	Potentiometric Fisher Model 640 Field pH Meter	080
Conductivity	0.2 umhos/cm	In situ measurement. Laboratory measurement. No preservative. The lab measurement was taken from the same as NH_3 below.	YSI Conductivity Meter Model 33 Radiometer Conductivity Meter (CDMC).	044

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Ammonia NH_3-N	0.0050 mg/L	Samples collected in 2 litre polyethylene containers. The container was rinsed 3 times with sample before it was filled. No preservatives. Stored at 4°C. Water samples at depth from lake stations were collected using a 2.5 Litre Nisken Water Sampler.	Phenol Hypochlorite-Colorimetric-Automated	058
Colour	5 (colour units)	Same sample as NH_3.	Platinum-Cobalt Visual Comparison	040
Turbidity	1.0 (FTU)	Same sample as NH_3.	Nephelometric Turbidity	130
Non-Filterable Residue (NFR)	5.0 mg/L	Same sample as NH_3.	Filtration, drying and weighing of residue on filter	104
Filterable Residue (FR)	10.0 mg/L	Same sample as NH_3.	Filtration, drying and weighing of filtrate	100
Total Alkalinity	1.0 mg/L as $CaCO_3$	Same sample as NH_3.	Potentiometric Titration	006
Total Phosphate T PO_4-P	0.005 mg/L	Same sample as NH_3.		
Nitrite NO_2-N	0.005 mg/L	Same sample as NH_3.		

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Nitrate NO_3-N	0.01 mg/L	Same sample as NH_3.	Cadmium Copper Reduction Colorimetric Automated	072
Nitrogen, total dissolved		Same sample as NH_3.	Autoclave Digestion followed by Potassium Sulfate Colormetric Automated	
Sulphate SO_4	1.0 mg/L	Same sample as NH_3.	Barium Chloranilate -UV Spectrophotometric	122
Chloride Cl	0.5 mg/L	Same sample as NH_3.	Thiocyanate-Combined Reagent-Colorimetric	024
Extractable Metals	mg/L	Samples collected in 100 ml linear polyethylene bottles. Each bottle was rinsed three times with sample before filling. Preserved to a pH <1.5 using 2.0 ml concentrated HNO_3. Water samples at depth from lake stations were collected using a 2.5 litre Nisken Water Sampler.	Inductively Coupled Argon Plasma	300
Al	0.05			
As	0.05			
B	0.001			
Ba	0.001			
Be	0.001			
Ca	0.050			
Cd	0.004			
Co	0.005			
Cr	0.005			
Cu	0.005			

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Extractable Metals	mg/L			
Fe	0.005			
Mg	0.10			
Mn	0.001			
Mo	0.005			
Na	0.2			
Ni	0.02			
Pb	0.04			
Sb	0.05			
Se	0.05			
Si	0.01			
Sn	0.01			
Sr	0.002			
Ti	0.002			
V	0.01			
Zn	0.002			
Cd	0.0005	Same as sample metals.	Flame Atomic Absorption Spectrophotometry	330
Cu	0.001	Same sample as metals.		
Pb	0.001	Same sample as metals.		
Ag	0.0005 mg/L	Same sample as metals.	Flame Atomatic Absorption Spectrophotometry	330
Total Hardness	0.030 mg/L as $CaCO_3$	Same sample as metals.	The sum of the ICAP results for Mg x 4.116 and Ca x 2.497 reported as mg/L $CaCO_3$	

1 As described in Environment Canada (1976).
2 As described in Department of Environment (1979).
3 As described in "Water Measurement Manual" United States Department of the Interior, Bureau of Reclamation (1975)

APPENDIX I TABLE 2 SEDIMENT COLLECTION, PREPARATION AND ANALYSIS METHODS

PARAMETER	COLLECTION/PREPARATION	ANALYSIS	METHOD CODE[1]
All Parameters	Creek and River Stations: Sediment samples were collected using one of two methods: High velocity streams -- In order to reduce the loss of fine sediment material in fast flowing streams, a 30 cm diameter stainless steel corer device is worked into the stream bed to a depth of 15 cm. Sediments are scooped by hand from inside corer device into an outside reservoir. Water and suspended sediments are also scooped into reservoir using a small cup. The sediments and water are then placed in an 8 litre plastic pail and are allowed to settle for approximately 10 minutes after which the water is decanted and the sediments placed in sample bags. Low velocity streams -- An aluminum shovel is used to scoop stream sediments into sample bag. Lake Stations: Sediment samples were collected using an Ekman Dredge. Three samples were collected at each station and placed in geochemical paper sample bags. Each sample is then sealed in plastic bags and frozen within 24 hours. Samples for hydrocarbon analysis were placed into heat treated glass containers and kept in cool storage.		

APPENDIX I TABLE 2 SEDIMENT COLLECTION, PREPARATION AND ANALYSIS METHODS

PARAMETER	COLLECTION/PREPARATION	ANALYSIS	METHOD CODE[1]
Metals (Leachable) Al, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Na, Ni, P, Pb, Si, Sn, Sr, Ti, V, Zn	Sample was freeze-dried for 48 hours to remove water. Sample was sieved through a size 100 mesh (.15 mm) stainless steel sieve. The portion passing through was analyzed for leachable metals. Sample was leached with HC and HNO_3. The sample was heated for 3 hours.	Inductively Coupled Argon Plasma (ICAP)	320

APPENDIX I TABLE 2 SEDIMENT COLLECTION, PREPARATION AND ANALYSIS METHODS (continued)

PARAMETER	PREPARATION	ANALYSIS	METHOD CODE[1]
Metals (Leachable) (continued)			
As	Same as other metals.	Hydride Generation ICAP	350
Ag	Same as other metals.	Flame Atomic Absorption Spectrophotometry	330
Particle Sizing	A dry, pre-weighed sample was passed through sieves of the following mesh size according to the Wentworth classification system: 2.0 mm, 1.0 mm, .5 mm, .25 mm, .15 mm, and .063 mm.	Dry sieve	078
Oils and grease	A sample of air dried sediment was placed in the Soxhlet apparatus with petroleum ether solvent. The solvent dissolves the oils and grease (including hydrocarbons, fatty acids, soaps, fats, waxes, oils and any other material which can be extracted by the solvent) which is then evaporated and the residue weighed.	Petroleum Ether Soxhlet Extraction	725

APPENDIX I TABLE 2 SEDIMENT COLLECTION, PREPARATION AND ANALYSIS METHODS (continued)

PARAMETER	PREPARATION	ANALYSIS	METHOD CODE[1]
	The sediment sample is dissolved in cyclo-hexane and the solution is analysed using the gas chromatograph to determine the presence of hydro-carbons and compared to the spectrum from known petroleum products.	Gas Chromatographic	

[1] Department of Environment, Department of Fisheries and Oceans, Laboratory Manual, Environmental Protection Fisheries and Marine Service (1979).

APPENDIX I TABLE 3 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
Physical				
Colour Pt. Counts	15	1		
Odour and taste	0	1		
Turbidity J.T.U.	5	1		
Chemical				
Alkalinity mg/L (Total)	Not considered a public health problem	4	>20	3
Aluminum (Al) mg/L	Not considered a public health problem	7	0.1	5
Ammonia (NH_3-N) mg/L	0.5 (Total)	4	0.02 (un-ionized)	3
Antimony (Sb) mg/L				
Arsenic (As) mg/L	0.05	1	0.05 (Total)	2
Barium (Ba) mg/L	1.0	1	5.0	7
Boron (Bo) mg/L	1.0	1		
Cadmium (Cd) mg/L	0.005	1	0.0002 (Total)	2
Calcium (Ca) mg/L	75-200	7		
Chloride (Cl)mg/L	250	1		
Chromium (Cr) mg/L	0.05	1	0.04 (Total)	2
Cobalt (Co) mg/L				
Conductivity @ 25°C (umhos/cm)	Depends on dissolved salts	7	150-500	6
Copper (Cu) mg/L	1.0	1	0.002 (Total)	2
Cyanide (CN) mg/L	0.2	1	0.005	3
Dissolved oxygen (% saturation)	Near 100%	4	$\geq$5.0 mg/L	3

APPENDIX I TABLE 3 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE (continued)

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
Fluoride (F) mg/L	1.5	1	1.5	7
Hardness (Total) as mg/l $CaCO_3$	80-100	1		
Iron (Fe) mg/L	0.3	1	1.0	3
Lead (Pb) mg/L	0.05	1	0.005 (soft H_2O*)(Total)	2
			0.01 (hard H_2O*) (Total)	2
Magnesium (Mg) mg/L	50	4		
Manganese (Mn) mg/L	0.05	1	1.0	7
Mercury (Hg) mg/L	0.002	1	0.0001-0.0002 (Total)	2
Molybdenum (Mo)				
Nickel (Ni) mg/L	0.25	2	0.025 (soft H_2O*) (Total)	2
			0.25 (hard H_2O*) (Total)	2
Nitrate (NO_3-N) mg/L	10	1		
Nitrite (NO_2-N) mg/L	0.001	1		
pH units	6.5 - 8.5	1	6.5 - 9.0	3
Phosphorus (P) mg/L (Total)			0.020 to prevent algae	5
Potassium (K) mg/L				
Residue: Filterable mg/L (Total dissolved solids)	1000	4	70 - 400 with a maximum of 2000	6
Residue: Non-Filterable (mg/)				
Selenium (Se) mg/L	0.01	1	0.01 (Total)	2
Silica (Si) mg/L				
Silver (Ag) mg/L	0.05	1	0.0001 (Total)	2
Sodium (Na) mg/L	20	1		
Strontium (Sr) mg/L	10	1		
Sulphate (SO_4) mg/L	500	1		
Tin (Sn) mg/L	Not present in natural waters	7		
Titanium (Ti) mg/L				

APPENDIX I TABLE 3 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE (continued)

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
Total Inorganic Carbon (TIC)				
Total Organic Carbon (TOC)	5.0	5		
Vanadium (V)				
Zinc (Zn) mg/l	5.0	1	0.030	5

* Soft water has a total hardness less than 95 mg/l as $CaCO_3$. Hard water has a total hardness of more than 95 mg/L as $CaCO_3$ (Reference 6).

REFERENCES:

1. Health & Welfare Canada, Guidelines for Canadian Drinking Water Quality 1978, Supply and Services, Canada (1979).

2. Inland Waters Directorate, Guidelines for Surface Water Quality, Vol. 1, Inorganic Chemical Substances. Environment Canada, Ottawa (1979, 1980).

3. Thurston, R.V., R.C. Russo, C.M. Fetteroff Jr., T.A. Edsall, and Y.M. Barber Jr. (Eds.), A Review of the EPA Red Book: Quality Criteria for Water. Water Quality Section, American Fisheries Society, Bethesda, MD, 313p. (1979).

4. Anonymous, Guidelines for Establishing Water Quality Objectives for the Territorial Waters of the Yukon and Northwest Territories. Report of the Working Group on Water Quality Objectives to the Chairmen, Water Boards, Yukon and Northwest Territories, July (1977).

5. Ontario Ministry of the Environment, Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment. (1978).

APPENDIX I TABLE 3 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE (continued)

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)

6. Environment Canada, Pollution Sampling Handbook. Pacific Region Laboratory Services, Fisheries Operations and Environmental Protection Service, West Vancouver, B.C. (1976).

7. California State Water Resources Control Board, Water Quality Criteria. Publication No. 3-A Second Edition by McKee and Wolf. (1963).

APPENDIX II

STREAM AND LAKE WATER QUALITY

APPENDIX II TABLE 1 STREAM WATER QUALITY

STATION	SAMPLE DATE	AVG. DEPTH (m)	WIDTH (m)	FLOW (m3/s)	TEMP. (C)	pH INSITU	pH LAB	COND. (umhos/cm) INSITU	COND. (umhos/cm) LAB	DISOLVED OXYGEN (mg/L)	%DO SATURATION	COLOR (FTU)
1	01-Aug-85	0.05	1.5	N/A	10.0	7.75	7.3	82	133	10.6	96	10
							7.3		133			10
							7.5		133			10
$\bar{x}$							7.4		133			10
SD							0.1		0			0
2	01-Aug-85	0.30	10.0	N/A	12.0	7.90	7.2	50	83	10.5	98	20
3	01-Aug-85	0.15	12.1	0.31	14.0	7.82	7.4	70	103	10.6	101	20
4	01-Aug-85	0.18	9.9	0.32	14.0	7.88	7.4	70	103	10.5	102	20
5	01-Aug-85	0.11	10.0	0.44	14.0	7.78	7.5	65	103	10.6	103	10
*A	17-Aug-73	N/A	N/A	0.48	8.5	N/A	7.8	N/A	150	12.6	N/A	N/A
*B	06-Aug-83	N/A	N/A	0.4	12.5	N/A	7.2	95	135	9.8	92	10
*C	07-Aug-83	N/A	N/A	1.6	12.5	N/A	7.4	95	138	9.9	93	40
*D	16-Jul-75	N/A	N/A	2.0	11.0	7.5	N/A	N/A	N/A	8.2	74	N/A
*E	20-Aug-75	N/A	N/A	0.86	12.1	8.0	N/A	N/A	N/A	12.0	111	N/A

N/A - Not available

*A - headwaters of Deep Creek, Craig and McCart (1974)
*B - headwaters of Deep Creek, Allan and Mackenzie-Grieve (1984)
*C - Deep Creek near Station 3, Allan and Mackenzie-Grieve (1984)
*D - Deep Creek near Station 3, F.F. Slaney and Co. Ltd. (1975)
*E - Deep Creek near Station 3, F.F. Slaney and Co. Ltd. (1975)

APPENDIX II TABLE 1 STREAM WATER QUALITY (cont'd)

STATION	SAMPLE DATE	T.ALK. (as CACO3) (mg/L)	T.HARD (as CaCO3) (mg/L)	SULFATE (mg/L)	CHLORIDE (mg/L)	TOTAL PHOSPHATE (mg/L)	NITRITE (mg/L)	NITRATE (mg/L)	AMMONIA (mg/L)	TDN (mg/L)	**ORGANIC N (mg/L)	FR (mg/L)	NFR (mg/L)
1	01-Aug-85	50.0	61.5	12.0	1.1	<0.002	<0.005	0.028	0.009	0.23	0.19	85	8
		49.1	61.7	12.0	1.0	<0.002	<0.005	0.026	0.006	0.26	0.23	83	<5
		49.1	62.0	12.0	1.0	<0.002	<0.005	0.027	0.006	0.24	0.21	84	<5
$\bar{x}$		49.4	61.7	12.0	1.0	0.000	0.0	0.027	0.007	0.24	0.21	84	3
SD		0.5	0.3	0.0	0.1	0.000	0.0	0.001	0.002	0.02	0.02	1	5
2	01-Aug-85	28.3	34.3	4.0	2.2	0.020	<0.005	<0.005	0.054	0.43	0.38	55	6
3	01-Aug-85	37.5	41.5	6.0	2.0	0.007	<0.005	<0.005	0.030	0.35	0.32	86	<5
4	01-Aug-85	38.7	45.4	5.0	2.5	0.008	<0.005	<0.005	0.023	0.32	0.30	73	9
5	01-Aug-85	38.3	42.7	5.0	7.5	0.005	<0.005	<0.005	0.020	0.31	0.29	62	<5
*B	06-Aug-83	17.5	59.5	44.0	<0.5	0.005	<0.005	0.01	<0.005	N/A	N/A	102	<5
*C	07-Aug-83	58.0	58.6	15.8	2.2	0.025	<0.005	0.01	0.017	N/A	N/A	112	12

N/A - Not available.

*B - headwaters of Deep Creek, Allan and Mackenzie-Grieve (1984)
*C - Deep Creek near Station 2, Allan and Mackenzie-Grieve (1984)
** - Organic N = TDN - (NO_2 + No_3 + NH_3)

APPENDIX II TABLE 1 STREAM WATER QUALITY (cont'd)
TOTAL METALS

STATION	SAMPLE DATE	Ag (mg/L)	Al (mg/L)	As (mg/L)	B (mg/L)	Ba (mg/L)	Be (mg/L)	Ca (mg/L)	Cd (mg/L)	Co (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	Hg (mg/L)
1	01-Aug-85	<0.0006	0.10	<0.05	<0.001	0.060	<0.001	16.9	<0.006	<0.005	<0.005	<0.001	0.115	0.00008
		<0.0006	0.06	<0.05	<0.001	0.060	<0.001	17.0	<0.006	<0.005	<0.005	0.002	0.103	<0.00005
		<0.0006	0.10	<0.05	<0.001	0.060	<0.001	17.1	<0.006	<0.005	<0.005	0.002	0.115	0.00014
	$\bar{x}$	0.0	0.09	0.0	0.000	0.060	0.0	17.0	0.000	0.0	0.0	0.001	0.111	0.00007
	SD	0.0	0.02	0.0	0.000	.000	0.0	0.1	0.000	0.0	0.0	0.001	0.007	0.00007
2	01-Aug-85	<0.0006	0.22	<0.05	0.012	0.046	<0.001	8.6	<0.006	<0.005	<0.005	0.003	0.640	0.00036
3	01-Aug-85	<0.0006	0.08	<0.05	0.012	0.052	<0.001	11.0	<0.006	<0.005	<0.005	0.002	0.368	0.00013
4	01-Aug-85	<0.0006	0.40	<0.05	<0.001	0.055	<0.001	11.5	<0.006	<0.005	<0.005	0.003	0.650	0.00027
5	01-Aug-85	<0.0006	0.16	<0.05	<0.001	0.048	<0.001	11.3	<0.006	<0.005	<0.005	<0.001	0.442	0.00017
*B	06-Aug-83	<0.0005	0.06	<0.0005	0.006	0.022	<0.001	14.3	<0.0005	<0.005	<0.005	<0.001	0.174	N/A
*C	07-Aug-83	<0.0005	0.19	<0.0005	0.006	0.071	<0.001	15.6	<0.0005	<0.005	<0.005	0.002	0.947	N/A

N/A - Not available

*B - headwaters of Deep Creek, Allan and Mackenzie-Grieve (1984)
*C - Deep Creek near Station 2, Allan and Makenzie-Grieve (1984)

APPENDIX II TABLE 1 STREAM WATER QUALITY (cont'd)
TOTAL METALS

STATION	SAMPLE DATE	Mg (mg/L)	Mn (mg/L)	Mo (mg/L)	Na (mg/L)	NI (mg/L)	P (mg/L)	Pb mg/L)	Sb (mg/L)	Se (mg/L)	SI (mg/L)	Sn (mg/L)	Sr (mg/L)	TI (mg/L)	V (mg/L)	Zn (mg/L)
1	01-Aug-85	4.5	0.018	<0.005	1.9	<0.02	<0.05	<0.001	<0.05	<0.05	1.7	<0.01	0.072	<0.002	<0.005	0.003
		4.5	0.018	<0.005	1.8	<0.02	<0.05	<0.001	<0.05	<0.05	1.8	0.02	0.073	<0.002	<0.005	<0.002
		4.5	0.018	<0.005	1.9	<0.02	<0.05	<0.001	<0.05	<0.05	1.7	<0.01	0.073	<0.002	<0.005	<0.002
	$\bar{x}$	4.5	0.018	0.0	1.9	0.0	0.00	0.00	0.0	0.0	1.7	0.01	0.073	0.0	0.0	0.001
	SD	0.0	0.000	0.0	0.1	0.0	0.00	0.00	0.0	0.0	0.0	0.01	0.001	0.0	0.0	0.002
2	01-Aug-85	2.5	0.029	<0.005	2.6	<0.02	<0.05	<0.001	<0.05	<0.05	0.6	<0.01	0.073	0.005	<0.005	<0.002
3	01-Aug-85	3.1	0.021	<0.005	2.9	<0.02	<0.05	<0.001	<0.05	<0.05	0.6	<0.01	0.085	<0.002	<0.005	<0.002
4	01-Aug-85	3.2	0.024	<0.005	3.0	<0.02	<0.05	0.003	<0.05	<0.05	0.6	<0.01	0.081	0.006	<0.005	0.006
5	01-Aug-85	3.1	0.017	<0.005	3.1	<0.02	<0.05	0.003	<0.05	<0.05	0.6	<0.01	0.075	0.004	<0.005	<0.002
*B	06-Aug-83	5.6	0.014	<0.005	0.8	<0.02	<0.05	<0.001	<0.05	<0.05	1.4	<0.01	0.065	0.003	<0.01	<0.002
*C	07-Aug-83	4.0	0.040	<0.005	5.3	<0.02	<0.05	<0.001	<0.05	<0.05	1.3	<0.01	0.112	0.007	<0.01	0.003

N/A - Not available

*B - headwaters of Deep Creek, Allan and Mackenzie-Grieve (1984)
*C - Deep Creek near Station 2, Allan and Mackenzie-Grieve (1984)

APPENDIX II TABLE 2 KING POINT LAKE WATER QUALITY

STATION	SAMPLE DATE	LAKE	MAX. DEPTH (m)	AREA (km2)	TEMP. (C)	pH		COND. (umhos/cm)		DISOLVED OXYGEN (mg/L)	%DO SATURATION	COLOR (FTU)	T.ALK. as CACO3 (mg/L)
						INSITU	LAB	INSITU	LAB				
6	02-Aug-85	A	4.0	0.31	11.0	8.04	7.5	350	115	11.2	102	5	30.8
7	02-Aug-85		4.0		11.0	8.04	7.5	370	115	11.0	100	5	31.2
8	02-Aug-85		10.8		11.0	8.04	7.5	370	115	10.8	96	5	30.4
9	02-Aug-85	B	5.0	0.45	11.0	7.88	7.3	65	93	11.2	102	5	23.3
10	02-Aug-85		5.8		11.0	7.88	7.3	65	93	11.0	100	5	23.3
11	02-Aug-85		4.6		11.0	7.78	7.4	65	93	11.4	104	5	22.9
12	03-Aug-85 C, surface		13.5	0.18	10.8	7.85	7.6	110	155	11.0	100	5	50.0
	03-Aug-85 C, bottom				10.0	7.99	7.7	120	155	11.0	100	5	49.6
13	03-Aug-85 C, surface		9.2		11.0	7.80	7.7	105	155	11.0	100	5	49.6
	03-Aug-85 C, bottom				10.8	7.79	7.7	120	150	10.6	96	5	50.0
14	03-Aug-85 C, surface		8.0		11.5	7.80	7.7	108	155	11.2	104	5	50.0
	03-Aug-85 C, bottom				11.0	7.81	7.7	120	155	11.2	102	5	50.0
Stokes Pt	Aug-83		N/A	N/A	N/A	7.6	N/A	40	N/A	N/A	92	15	12.0
*King Pt.	Aug-84	B	5.5	0.45	11.5	N/A	7.00	55	90.8	N/A	N/A	<5	20.9
**Lake 5	20-Aug-75		N/A	N/A	11.0	8.0	N/A	N/A	N/A	11.0	99	N/A	N/A
**Lake 6	20-Aug-75		N/A	N/A	11.1	8.0	N/A	N/A	N/A	10.0	90	N/A	N/A

N/A - Not Available
* - Mean of six samples
** - F.F. Slaney and Co. Ltd. (1975)

APPENDIX II TABLE 2 KING POINT LAKE WATER QUALITY (cont'd)

STATION	SAMPLE DATE	LAKE	T.HARD (as CaCO3) (mg/L)	SULFATE (mg/L)	CHLORIDE (mg/L)	TOTAL PHOSPHATE (mg/L)	NITRITE (mg/L)	NITRATE (mg/L)	AMMONIA (mg/L)	TDN (mg/L)	**ORGANIC N (mg/L)	FR (mg/L)	NFR (mg/L)
6	02-Aug-85	A	34.2	2.0	13.3	0.003	<0.005	<0.005	0.019	0.22	0.20	68	6
7	02-Aug-85		34.4	2.0	13.3	0.015	<0.005	0.007	0.017	0.22	0.20	59	<5
8	02-Aug-85		34.9	1.0	13.6	<0.002	<0.005	<0.005	0.023	0.22	0.20	69	<5
9	02-Aug-85	B	27.1	1.0	11.8	<0.002	<0.005	<0.005	0.014	0.23	0.22	54	<5
10	02-Aug-85		27.1	1.0	11.8	0.002	<0.005	<0.005	0.015	0.23	0.22	55	<5
11	02-Aug-85		27.2	1.0	11.8	0.002	<0.005	<0.005	0.015	0.22	0.21	55	6
12	03-Aug-85	C, surface	58.1	4.0	12.3	<0.002	<0.005	<0.005	0.018	0.23	0.21	83	<5
	03-Aug-85	C, bottom	57.7	4.0	12.2	0.003	<0.005	<0.005	0.011	0.20	0.19	86	<5
13	03-Aug-85	C, surface	57.6	4.0	12.1	0.003	<0.005	<0.005	0.011	0.19	0.18	91	<5
	03-Aug-85	C, bottom	60.4	4.0	12.0	0.005	<0.005	<0.005	0.010	0.20	0.19	89	7
14	03-Aug-85	C, surface	57.6	4.0	12.1	<0.002	<0.005	<0.005	0.011	0.19	0.18	86	<5
	03-Aug-85	C, bottom	N/A	4.0	12.1	0.004	<0.005	<0.005	0.008	0.19	0.18	89	<5
Stokes Pt	Aug-83		13.1	4.3	3.6	0.083	<0.005	<0.01	0.032	N/A	N/A	N/A	9
*King Pt.	B Aug-84		N/A	1	13.6	0.007	<0.005	<0.01	0.022	N/A	N/A	N/A	<5

N/A - Not available

* - Mean of six samples

** - organic N = TDN - (NO_{2-3} + NH_4)

APPENDIX II TABLE 2 KING POINT LAKE WATER QUALITY (cont'd)
TOTAL METALS

STATION	SAMPLE DATE	LAKE	Ag (mg/L)	Al (mg/L)	As (mg/L)	B (mg/L)	Ba (mg/L)	Be (mg/L)	Ca (mg/L)	Cd (mg/L)	Co (mg/L)
6	02-Aug-85	A	<0.0006	<0.05	<0.05	<0.001	0.022	<0.001	8.8	<0.006	<0.005
7	02-Aug-85		<0.0006	<0.05	<0.05	<0.001	0.022	<0.001	8.8	<0.006	<0.005
8	02-Aug-85		<0.0006	<0.05	<0.05	<0.001	0.022	<0.001	8.9	<0.006	<0.005
9	02-Aug-85	B	<0.0006	<0.05	<0.05	<0.001	0.018	<0.001	6.6	<0.006	<0.005
10	02-Aug-85		<0.0006	<0.05	<0.05	<0.001	0.018	<0.001	6.6	<0.006	<0.005
11	02-Aug-85		<0.0006	<0.05	<0.05	<0.001	0.018	<0.001	6.7	<0.006	<0.005
12	03-Aug-85	C, surface	<0.0006	0.08	<0.05	<0.001	0.031	<0.001	16.1	<0.006	<0.005
	03-Aug-85	C, bottom	<0.0006	<0.05	<0.05	<0.001	0.041	<0.001	16.0	<0.006	<0.005
13	03-Aug-85	C, surface	<0.0006	0.05	<0.05	<0.001	0.031	<0.001	15.9	<0.006	<0.005
	03-Aug-85	C, bottom	<0.0006	0.25	<0.05	<0.001	0.046	<0.001	16.1	<0.006	<0.005
14	03-Aug-85	C, surface	<0.0006	<0.05	<0.05	<0.001	0.030	<0.001	16.0	<0.006	<0.005
	03-Aug-85	C, bottom	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stokes Pt	Aug-83		<0.03	0.09	0.003	N/A	0.016	<0.001	3.6	<0.0005	<0.005
* King Pt. B	Aug-84		N/A	<0.05	<0.05	0.024	0.021	<0.001	6.5	<0.002	<0.005

N/A - Not available
* - Mean of six samples

APPENDIX II TABLE 2 KING POINT LAKE WATER QUALITY (cont'd)
TOTAL METALS

STATION	SAMPLE DATE	LAKE	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	Hg (mg/L)	Mg (mg/L)	Mn (mg/L)	Mo (mg/L)	Na (mg/L)	NI (mg/L)	P (mg/L)
6	02-Aug-85	A	<0.005	<0.001	0.045	0.00010	3.0	0.011	<0.005	3.0	<0.02	<0.05
7	02-Aug-85		<0.005	<0.001	0.043	0.00027	3.0	0.011	<0.005	6.5	<0.02	<0.05
8	02-Aug-85		<0.005	<0.001	0.046	0.00015	3.0	0.012	<0.005	6.5	<0.02	<0.05
9	02-Aug-85	B	<0.005	0.002	0.073	0.00054	2.5	0.011	<0.005	5.8	<0.02	<0.05
10	02-Aug-85		<0.005	<0.001	0.063	0.00016	2.5	0.009	<0.005	5.8	<0.02	<0.05
11	02-Aug-85		<0.005	<0.001	0.065	0.00025	2.5	0.009	<0.005	5.7	<0.02	<0.05
12	03-Aug-85	C, surface	<0.005	<0.001	0.029	0.00022	4.2	0.007	<0.005	6.1	<0.02	<0.05
	03-Aug-85	C, bottom	<0.005	<0.001	0.033	0.00033	4.2	0.007	<0.005	6.1	<0.02	<0.05
13	03-Aug-85	C, surface	<0.005	<0.001	0.052	0.00018	4.2	0.008	<0.005	6.1	<0.02	<0.05
	03-Aug-85	C, bottom	<0.005	<0.001	0.495	0.00015	4.3	0.152	<0.005	6.1	<0.02	0.06
14	03-Aug-85	C, surface	<0.005	<0.001	0.049	0.00180	4.2	0.007	<0.005	6.1	<0.02	<0.05
	03-Aug-85	C, bottom	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stokes Pt	Aug-83		<0.005	0.007	0.758	<0.0002	1.0	0.029	<0.005	2.1	<0.02	<0.05
*King Pt.	B Aug-84		<0.005	<0.005	<0.005	N/A	2.5	0.006	<0.005	6.0	<0.02	<0.05

N/A - Not available
* - Mean of six samples

APPENDIX II TABLE 2 KING POINT LAKE WATER QUALITY (cont'd)
TOTAL METALS

STATION	SAMPLE DATE	LAKE	Pb (mg/L)	Sb (mg/L)	Se (mg/L)	Si (mg/L)	Sn (mg/L)	Sr (mg/L)	Ti (mg/L)	V (mg/L)	Zn (mg/L)
6	02-Aug-85	A	0.004	<0.05	<0.05	<.1	<0.01	0.029	<0.002	<0.005	0.012
7	02-Aug-85		0.001	<0.05	<0.05	0.2	<0.01	0.029	<0.002	<0.005	0.004
8	02-Aug-85		<0.001	<0.05	<0.05	0.2	<0.01	0.029	<0.002	<0.005	<0.002
9	02-Aug-85	B	0.005	<0.05	<0.05	0.2	0.01	0.024	<0.002	<0.005	0.005
10	02-Aug-85		0.001	<0.05	<0.05	0.4	0.01	0.024	<0.002	<0.005	<0.002
11	02-Aug-85		0.001	<0.05	<0.05	0.2	<0.01	0.024	<0.002	<0.005	0.007
12	03-Aug-85	C, surface	0.002	<0.05	<0.05	0.5	<0.01	0.048	<0.002	<0.005	<0.002
	03-Aug-85	C, bottom	0.003	<0.05	<0.05	0.5	<0.01	0.049	<0.002	<0.005	<0.002
13	03-Aug-85	C, surface	<0.001	<0.05	<0.05	0.5	<0.01	0.048	<0.002	<0.005	<0.002
	03-Aug-85	C, bottom	0.001	<0.05	<0.05	0.5	<0.01	0.048	0.002	<0.005	<0.002
14	03-Aug-85	C, surface	<0.001	<0.05	<0.05	0.5	<0.01	0.048	<0.002	<0.005	0.003
	03-Aug-85	C, bottom	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stokes Pt	Aug-83		0.001	<0.05	<0.05	0.4	<0.01	0.013	<0.002	<0.01	0.026
*King Pt.	B Aug-84		<0.02	<0.05	<0.05	<0.1	<0.01	0.025	<0.002	<0.01	<0.002

N/A - Not available
* - Mean of six samples

APPENDIX III

STREAM AND LAKE SEDIMENTS

APPENDIX III TABLE 1 PERCENT PARTICLE SIZE DISTRIBUTION IN STREAM SEDIMENTS

STATION	SAMPLE NUMBER	SIZE RANGE (mm) >2.0 Gravel	2.0-1.0 Very Coarse Sand	1.0-0.5 Coarse Sand	0.5-0.25 Medium Sand	0.25-0.125 Fine Sand	0.125-0.063 Very Fine Sand	<0.063 Silt & Clay
1	1	72.0	9.2	6.7	8.1	2.6	0.9	0.6
	2	78.5	5.1	7.0	7.3	1.1	0.6	0.4
	3	57.1	11.8	12.3	14.1	2.6	1.2	0.9
$\bar{x}$		69.2	8.7	8.7	9.8	2.1	0.9	0.6
SD		11.0	3.4	3.2	3.7	0.9	0.3	0.3
2	4	52.5	2.9	2.9	27.1	10.2	2.0	2.3
	5	35.8	6.6	5.5	33.3	12.3	2.3	4.2
	6	16.6	1.7	3.8	49.5	19.3	4.1	4.9
$\bar{x}$		35.0	3.7	4.1	36.6	13.9	2.8	3.8
SD		18.0	2.6	1.3	11.6	4.8	1.1	1.3
3	7	89.6	4.9	2.9	1.2	0.4	0.4	0.6
	8	69.6	4.9	6.0	9.2	4.2	3.1	3.0
	9	85.1	5.6	4.4	2.4	0.8	0.8	1.0
$\bar{x}$		81.4	5.1	4.4	4.3	1.8	1.4	1.5
SD		10.5	0.4	1.6	4.3	2.1	1.5	1.3
4	10	80.8	5.7	5.5	5.8	1.7	0.4	0.3
	11	53.0	10.5	13.8	19.3	2.7	0.5	0.2
	12	50.6	10.8	14.1	17.5	5.4	1.2	0.3
$\bar{x}$		61.5	9.0	11.1	14.2	3.3	0.7	0.3
SD		16.8	2.9	4.9	7.4	1.9	0.4	0.1
5	13	74.8	6.9	9.6	4.8	1.4	1.2	1.3
	14	78.2	5.7	7.6	5.5	1.2	0.8	1.0
	15	75.4	9.1	7.6	3.9	1.1	1.1	1.7
$\bar{x}$		76.1	7.2	8.3	4.7	1.2	1.0	1.3
SD		1.8	1.7	1.2	0.8	0.2	0.2	0.4

APPENDIX III TABLE 2 PERCENT PARTICLE SIZE DISTRIBUTION IN LAKE SEDIMENTS

STATION	LAKE	SAMPLE NUMBER	SIZE RANGE (mm) >2.0 Gravel	2.0-1.0 Very Coarse Sand	1.0-0.5 Coarse Sand	0.5-0.25 Medium Sand	0.25-0.125 Fine Sand	0.125-0.063 Very Fine Sand	<0.063 Silt & Clay
6	A	16	0.5	0.5	1.0	15.5	30.3	37.7	14.6
7		17	0.4	0.6	1.2	9.8	16.2	45.8	26.0
8		18	4.3	4.8	7.8	18.4	20.0	25.2	19.4
$\bar{x}$			1.7	2.0	3.3	14.6	22.2	36.2	20.0
SD			2.2	2.5	3.9	4.4	7.3	10.4	5.7
9	B	19	0.1	0.4	0.8	7.6	36.4	32.4	22.3
10		20	0.1	0.5	1.0	17.0	25.0	28.9	27.4
11		21	0.1	0.2	0.5	2.3	12.9	69.6	14.4
$\bar{x}$			0.1	0.4	0.8	9.0	24.8	43.6	21.4
SD			.0	0.2	0.3	7.4	11.8	22.6	6.6
12	C	22	61.2	7.8	12.4	14.9	3.3	0.4	0.1
13		23	64.5	7.2	12.2	13.0	2.7	0.4	0.1
14		24	62.1	9.0	12.3	13.7	2.7	0.2	0.0
$\bar{x}$			62.6	8.0	12.3	13.9	2.9	0.3	0.1
SD			1.7	0.9	0.1	1.0	0.3	0.1	0.1

APPENDIX III TABLE 3 OILS AND GREASES AND LEACHABLE METALS IN STREAM SEDIMENTS

STATION	SAMPLE NUMBER	OILS & GREASE (mg/Kg)	Ag (mg/Kg)	Al (mg/Kg)	As (mg/Kg)	Ba (mg/Kg)	Be (mg/Kg)	Ca (mg/Kg)
1	1	<100	<0.08	13800	<8	198	0.4	2870
	2	<100	<0.08	14900	<8	213	0.5	3170
	3	<100	<0.08	15000	<8	201	0.5	3170
$\bar{x}$		<100	<0.08	14600	<8	204	0.5	3070
SD		0	0	666	0	8	0.1	173
2	4	<100	<0.08	18900	<8	500	0.6	3880
	5	<100	<0.08	19500	<8	602	0.5	3760
	6	<100	<0.08	17600	<8	445	0.5	3490
$\bar{x}$		<100	<0.08	18700	<8	516	0.5	3710
SD		0	0	971	0	80	0.1	200
3	7	<100	<0.08	18700	<8	244	0.5	3630
	8	<100	<0.08	17300	<8	223	0.5	3390
	9	<100	<0.08	18700	<8	253	0.5	3750
$\bar{x}$		<100	<0.08	18200	<8	240	0.5	3590
SD		0	0	808	0	15	0.0	183
4	10	<100	<0.08	16900	<8	472	0.6	9620
	11	<100	<0.08	14100	<8	376	0.4	4160
	12	<100	<0.08	13700	<8	266	0.4	3970
$\bar{x}$		<100	<0.08	14900	<8	371	0.5	5920
SD		0	0	1740	0	103	0.1	3209
5	13	<100	<0.08	18600	<8	211	0.5	4720
	14	<100	<0.08	18700	<8	217	0.5	4980
	15	<100	<0.08	19600	<8	228	0.6	5480
$\bar{x}$		<100	<0.08	19000	<8	219	0.5	5060
SD		0	0	551	0	9	0.1	386

APPENDIX III TABLE 3 OILS AND GREASES AND LEACHABLE METALS IN STREAM SEDIMENTS (cont'd)

STATION	SAMPLE NUMBER	Cd (mg/Kg)	Co (mg/Kg)	Cr (mg/Kg)	Cu (mg/Kg)	Fe (mg/Kg)	Hg (mg/Kg)	Mg (mg/Kg)
1	1	<3	9.5	21.1	17.2	27700	0.106	3740
	2	<3	17.1	23.9	18.6	31100	0.117	3980
	3	<3	9.5	23.5	17.6	29800	0.121	3990
$\bar{x}$		<3	12.0	22.8	17.8	29500	0.115	3900
SD		0	4.4	1.5	0.7	1720	0.008	142
2	4	<3	15.7	29.8	27.1	46500	0.157	6230
	5	<3	13.0	30.3	26.8	40000	0.171	6460
	6	<3	13.0	28.0	24.6	39300	0.156	5820
$\bar{x}$		<3	13.9	29.4	26.2	41900	0.161	6170
SD		0	1.6	1.2	1.4	3970	0.008	324
3	7	<3	7.1	26.9	25.6	36100	0.147	5820
	8	<3	8.8	25.4	23.3	33400	0.142	5190
	9	<3	9.4	26.8	25.0	36200	0.148	5840
$\bar{x}$		<3	8.4	26.4	24.6	35200	0.146	5620
SD		0	1.2	0.8	1.2	1590	0.003	370
4	10	<3	12.9	26.9	24.8	42700	0.159	7810
	11	<3	13.1	23.5	23.2	34400	0.139	4560
	12	<3	7.9	22.3	16.0	30800	0.114	4270
$\bar{x}$		<3	11.3	24.2	21.3	36000	0.137	5550
SD		0	2.9	2.4	4.7	6100	0.023	1960
5	13	<3	9.2	27.5	25.5	36100	0.158	5710
	14	<3	10.0	27.5	24.1	35300	0.136	6030
	15	<3	15.0	28.6	27.2	36600	0.167	6560
$\bar{x}$		<3	11.4	27.9	25.6	36000	0.154	6100
SD		0	3.1	0.6	1.6	656	0.016	429

APPENDIX III TABLE 3 OILS AND GREASES AND LEACHABLE METALS IN STREAM SEDIMENTS (cont'd)

STATION	SAMPLE NUMBER	Mn (mg/Kg)	Mo (mg/Kg)	Na (mg/Kg)	NI (mg/Kg)	P (mg/Kg)	Pb (mg/Kg)	SI (mg/Kg)
1	1	586	<0.8	110	21	719	14	840
	2	717	<0.8	120	23	778	17	610
	3	615	<0.8	120	22	762	12	740
$\bar{x}$		639	<0.8	117	22	753	14	730
SD		69	0	6	1	31	3	115
2	4	620	<0.8	190	35	1540	19	690
	5	804	<0.8	180	32	1340	15	530
	6	560	<0.8	200	32	1330	14	510
$\bar{x}$		661	<0.8	190	33	1400	16	577
SD		127	0	10	2	118	3	99
3	7	572	<0.8	200	28	1060	13	460
	8	583	<0.8	160	29	1050	14	460
	9	658	<0.8	180	29	1080	14	380
$\bar{x}$		604	<0.8	180	29	1060	14	433
SD		47	0	20	1	15	1	46
4	10	906	<0.8	200	28	1470	16	580
	11	622	<0.8	190	26	1370	16	460
	12	572	<0.8	160	25	1310	10	380
$\bar{x}$		700	<0.8	183	26	1380	14	473
SD		180	0	21	2	81	3	101
5	13	424	<0.8	170	26	1090	14	570
	14	592	<0.8	200	28	1060	13	470
	15	563	<0.8	220	29	1100	16	480
$\bar{x}$		526	<0.8	197	28	1080	14	507
SD		90	0	25	2	21	2	55

APPENDIX III TABLE 2 OILS AND GREASES AND LEACHABLE METALS IN STREAM SEDIMENTS (cont'd)

STATION	SAMPLE NUMBER	Sn (mg/Kg)	Sr (mg/Kg)	Tl (mg/Kg)	V (mg/Kg)	Zn (mg/Kg)
1	1	2	22.0	38.6	41.6	83.1
	2	<2	22.3	28.1	45.7	85.9
	3	<2	22.9	35.2	45.2	87.7
$\bar{x}$		<2	22.4	34.0	44.2	85.6
SD		0	0.5	5.4	2.2	2.3
2	4	4	37.9	34.3	62.5	126
	5	3	36.4	25.1	59.5	118
	6	<2	34.2	20.6	55.9	112
$\bar{x}$		<4	36.2	26.7	59.3	119
SD		0	1.9	7.0	3.3	7.0
3	7	<2	31.3	6.4	52.2	98.2
	8	<2	30.7	11.3	50.0	95.0
	9	2	33.0	5.6	52.5	98.1
$\bar{x}$		<2	31.7	7.8	51.6	97.1
SD		0	1.2	3.1	1.4	1.8
4	10	<2	43.3	25.3	59.3	104
	11	<2	35.1	21.3	48.4	100
	12	<2	30.5	13.6	46.4	90.5
$\bar{x}$		<2	36.3	20.1	51.4	98.2
SD		0	6.5	5.9	6.9	6.9
5	13	<2	32.5	9.9	52.8	96.3
	14	<2	32.3	9.4	54.1	96.4
	15	3	33.5	8.7	55.1	101
$\bar{x}$		<3	32.8	9.3	54.0	97.9
SD		0	0.6	0.6	1.2	2.7

APPENDIX III TABLE 4 OILS AND GREASES AND LEACHABLE METALS IN LAKE SEDIMENTS

STATION	SAMPLE NUMBER	OILS & GREASE (mg/Kg)	Ag (mg/Kg)	Al (mg/Kg)	As (mg/Kg)	Ba (mg/Kg)	Be (mg/Kg)	Ca (mg/Kg)	Cd (mg/Kg)	Co (mg/Kg)
Lake A 1	16	700	<0.08	17300	<8	198	0.7	3250	<3	10.9
2	17	500	<0.08	13900	<8	170	0.5	2620	<3	10.6
3	18	700	<0.08	16500	<8	209	0.6	3480	<3	8.0
$\bar{x}$		633	<0.08	15900	<8	192	0.6	3120	<3	9.8
SD		115	0	1778	0	20	0.1	445	0	1.6
Lake B 1	19	400	<0.08	19600	<8	316	0.7	2660	<3	15.0
2	20	500	<0.08	15500	<8	163	0.5	2500	<3	7.2
3	21	0	<0.08	14300	<8	165	0.5	2850	<3	11.0
$\bar{x}$		300	<0.08	16500	<8	215	0.6	2670	<3	11.1
SD		265	0	2779	0	88	0.1	175	0	3.9
Lake C 1	22	<100	<0.08	17100	<8	222	0.6	3570	<3	9.9
2	23	<100	<0.08	17200	<8	225	0.6	3870	<3	15.2
3	24	<100	<0.08	17000	<8	259	0.6	4050	<3	14.6
$\bar{x}$		<100	<0.08	17100	<8	235	0.6	3830	<3	13.2
SD		0	0	100	0	21	.0	242	0	2.9

APPENDIX III TABLE 4 OILS AND GREASES AND LEACHABLE METALS IN LAKE SEDIMENTS (cont'd)

STATION	SAMPLE NUMBER	Cr (mg/Kg)	Cu (mg/Kg)	Fe (mg/Kg)	Hg (mg/Kg)	Mg (mg/Kg)	Mn (mg/Kg)	Mo (mg/Kg)	Na (mg/Kg)	NI (mg/Kg)
Lake A 1	16	24.0	21.5	26300	0.173	4160	286	<0.8	210	22
2	17	21.2	19.0	26100	0.160	3510	256	<0.8	170	21
3	18	24.6	22.2	27500	0.198	3890	223	<0.8	210	23
$\bar{x}$		23.3	20.9	26600	0.177	3850	255	<0.8	197	22
SD		1.8	1.7	757	0.019	327	32	0	23	1
Lake B 1	19	28.8	28.3	76900	0.195	4220	1460	<0.8	290	24
2	20	23.5	20.0	23000	0.154	3610	149	<0.8	190	22
3	21	21.1	13.6	25100	0.094	3740	271	<0.8	230	21
$\bar{x}$		24.5	20.6	41700	0.148	3860	627	<0.8	237	22
SD		3.9	7.4	30500	0.051	321	724	0	50	2
Lake C 1	22	25.8	17.5	40600	0.121	4440	660	<0.8	210	29
2	23	29.2	18.2	42100	0.124	4590	746	<0.8	220	30
3	24	26.1	18.8	44300	0.112	4580	773	<0.8	210	29
$\bar{x}$		27.0	18.2	42300	0.119	4540	726	<0.8	213	29
SD		1.9	0.7	1860	0.006	84	59	0	6	1

APPENDIX III TABLE 4 OILS AND GREASES AND LEACHABLE METALS IN LAKE SEDIMENTS (cont'd)

STATION	SAMPLE NUMBER	P (mg/Kg)	Pb (mg/Kg)	SI (mg/Kg)	Sn (mg/Kg)	Sr (mg/Kg)	TI (mg/Kg)	V (mg/Kg)	Zn (mg/Kg)
Lake A 1	16	986	17	470	<2	23.7	0.6	43.8	99.6
2	17	947	16	620	3	22.0	17.5	42.4	79.2
3	18	951	16	440	<2	25.4	5.1	47.5	93.2
$\bar{x}$		961	16	510	<3	23.7	7.7	44.6	90.7
SD		21	1	96	0	1.7	8.8	2.6	10.4
Lake B 1	19	1920	32	540	3	25.7	11.6	64.3	110.0
2	20	857	14	520	<2	24.3	17.9	47.2	79.3
3	21	911	12	530	3	23.1	18.3	43.3	75.0
$\bar{x}$		1230	19	530	<3	24.4	15.9	51.6	88.1
SD		599	11	10	0	1.3	3.8	11.2	19.1
Lake C 1	22	1560	16	480	<2	34.3	11.5	57.1	104.0
2	23	1710	18	540	3	33.1	19.2	58.3	105.0
3	24	1820	18	630	4	36.7	22.1	59.5	110.0
$\bar{x}$		700	17	550	<4	34.7	17.6	58.3	106.3
SD		131	1	75	0	1.8	5.5	1.2	3.2

APPENDIX IV

STREAM AND LAKE BOTTOM FAUNA

APPENDIX IV TABLE 1 STREAM AND LAKE INVERTEBRATE TAXANOMIC LIST

NUMBER	CLASSIFICATION	INVERTEBRATE
	Phylum:	Coelenterata
	Class:	Hydrozoa
	Order:	Hydroida
	Family:	Hydridae
1		Hydra sp.
	Phylum:	Platyhelminthes
	Class:	Turbellaria
2		(Hymanella sp.)
3	Phylum:	Nematoda
	Phylum:	Annelida
4	Class:	Oligochaeta
	Order:	Haplotaxida
5	Family:	Enchytraeidae
6		Nais sp.
7		Nais (communis or variabilis)
8	Family:	Tubificidae (unid., juv.)
9		Tubifex sp.
	Order:	Lumbriculida
	Family:	Lumbriculidae
10		Kincaidiana hexatheca
11		Lumbirculus variegatus
	Class:	Polychaeta
12		Manayunkia speciosa
	Phylum:	Copepoda
13	Suborder:	Calanoida unid.
	Family:	Temoridae
14		Eurytemora affinis
	Family:	Diaptomidae
15		Diaptomus sp.
16	Class:	Ostracoda
	Order:	Amphipoda
	Family:	Gammaridae
17		Gammarus (lacustris)
	Class:	Arachnoida
18	Order:	Acari
	Phylum:	Arthropoda
	Class:	Crustacea
	Order:	Cladocera
19		Bosmina longirostris
20	Class:	Insecta (unid.)
21	Order:	Collembola (Poduridae)
	Order:	Plecoptera
	Family:	Nemouridae
22		Podmosta sp.
	Family:	Chloroperlidae
23		Utaperla sp.
	Order:	Ephemeroptera
	Family:	Baetidae
24		Baetis (hudsonicus)

APPENDIX IV TABLE 1 STREAM AND LAKE INVERTEBRATE TAXANOMIC LIST (cont'd)

NUMBER	CLASSIFICATION	INVERTEBRATE
25		*Baetis (insignificans)*
26		*Baetis* sp.
	Family:	Heptageliidae
27		*Cinygmula* sp.
28		*Cinygmula* sp.
29	Order:	Hemiptera (unid. nymph)
	Order:	Trichoptera
	Family:	Brachycentridae
30		*Brachycentrus* sp.
	Family:	Tipulidae
31		*Tipula* sp.
	Order:	Diptera
	Family:	Simuliidae
32		*Simulium* sp.
33		*Simulium* sp.
34		*Cricotopus* sp.
	Subfamily:	Tanypodinae
35		*Procladius* sp.
36		*Paralauterborniella* sp.
	Subfamily:	Chironomini
37		*Micropsectra* sp.
38		*Tribelos* sp.
39		*Chironomus* sp.
40		*Eukiefferiella* sp.
41		*Brillia* sp.
42	Subfamily:	Orthocladiinae (unid.)
43		*Corynoneura* sp.
44		*Cardiocladius* sp.
45		*Rheotanytarsus* sp.
46		*Glyptotendipes* sp.
47		*Stenochironomus* sp.
48		*Stenochironomus* sp. pupae
	Family:	Chironomidae
49		Chironomidae pupae
	Phylum:	Mollusca
	Order:	Gastropoda
	Family:	Lymnaeidae
50		*Stagnicola (kennicotte)*
	Family:	Valvatidae
51		*Valvata sincera*
52		egg mass (Gastropoda)
	Order:	Pelecypoda
		Sphaeriidae
53		unid. juvinile
54		*Pisidium casertanum*
55		egg mass (snail)
56		egg mass (insect)

APPENDIX IV TABLE 2 STREAM INVERTEBRATE PERCENT DISTRIBUTION

NUMBER	INVERTEBRATE	STA. 1	%	STA. 2	%	STA. 4	%	STA. 5	%
1	Hydra sp.	1	0.4						
3	Nematoda	2	0.8	346	52.2	96	18.1	38	18.5
4	Oligochaeta eggs			4	0.6	3	0.6		
5	Kincaidian hexatheca					10	1.9		
6	Enchytraeidae	2	0.8	5	0.8	6	1.1		
7	Tubificidae, unid., juv.	2	0.8	28	4.2	5	0.9		
8	Tubifex sp.					13	2.4		
10	Nais sp.			4	0.6	6	1.1	2	1.0
11	Nais (communis or variabilis)			1	0.2	1	0.2		
12	*Manyunkia speciosa			1	0.2			1	0.5
13	Calanoida unid.			2	0.3				
14	*Eurytemora affinis			5	0.8	2	0.4		
16	Ostracoda			3	0.5				
18	Acari	11	4.2	27	4.1	3	0.6	2	1.0
19	Bosmina longirostris					3	0.6		
21	Collembola (Poduridae)	1	0.4						
22	Podmosta sp.	85	32.3	6	0.9	1	0.2	2	1.0
23	Utaperla sp.	2	0.8	1	0.2				
24	Baetis (hudsonicus)	62	23.6	62	9.4	41	7.7	20	9.8
25	Baetis (insignificans)	3	1.1	7	1.1	14	2.6		
26	Baetis sp.							1	0.5
27	Cinygmula sp.							22	10.7
28	**(Cinygmula sp.)	45	17.1	24	3.6	9	1.7	3	1.5
29	Hemiptera (unid. nymph)			1	0.2				
30	Brachycentrus sp.	24	9.1	33	5.0	1	0.2	45	22.0
31	Tipula sp.	2	0.8	1	0.2				
32	Simulium sp. pupae			3	0.5			1	0.5
33	Simulium sp. larvae			3	0.5				
34	Cricotopus sp.	6	2.3	16	2.4	12	2.3	11	5.4
35	Procladius sp.	2	0.8	2	0.3				
36	Paralauterborniella sp.	2	0.8					1	0.5
37	Micropsectra sp.	2	0.8	49	7.4	231	43.5	35	17.1
38	Tribelos sp.	4	1.5			34	6.4	4	2.0
40	Eukiefferiella sp.	3	1.1	8	1.2	3	0.6	1	0.5
41	Brillia sp.			10	1.5	32	6.0	9	4.4
42	Orthocladiinae (unid.)	2	0.8	4	0.6				
43	Corynoneura sp.			1	0.2	2	0.4		
44	Cardiocladius sp.			4	0.6			5	2.4
49	Chironomidae pupae			1	0.2	2	0.4	2	1.0
51	Valvata sincera			1	0.2	1	0.2		
TOTAL		263		663		531		205	
DENSITY/m^2		974		2456		1967		759	

*Manayunkia sp. and Eurytemora sp. are facultatively marine species (Dr. C. Low, personal comm. Sept. 31, 1985)
** identification tentative, possibly and undescribed species (Dr. C. Low, personal comm., Sept. 31, 1985).

APPENDIX IV TABLE 3 LAKE INVERTEBRATE PERCENT DISTRIBUTION

NUMBER	INVERTEBRATE	LAKE A	%	LAKE B	%
1	Hydra sp.	1	0.5		
2	(Hymanella sp.)	1	0.5	3	1.3
3	Nematoda			9	4.0
6	Nais sp.				
9	Tubifex sp.			82	36.4
11	Lumbriculus variegatus	1	0.5		
14	Eurytemora affinis	1	0.5		
15	Diaptomus sp.	1	0.5	1	0.4
16	Ostracoda			1	0.4
17	Gammarus (lacustris)			7	3.1
18	Acari	1	0.5		
20	Insecta (unid.)	1	0.5		
35	Procladius sp.			5	2.2
37	Micropsectra sp.	93	45	17	7.6
38	Tribelos sp.			21	9.3
39	Chironomus sp.			20	8.9
40	Eukiefferiella sp.			3	1.3
41	Brilia sp.			2	0.9
45	Rheotanytarsus sp.	1	0.5		
46	Glyptotendipes sp.	2	1.0		
47	Stenochironomus sp.	29	13.9		
48	Stenochironomus sp. pupae	1	0.5		
49	Chironomidae pupae	3	1.0		
50	Stagnicola (kennicotte)	3	1.0	3	1.3
51	Valvata sincera	50	24.0	9	4.0
52	egg mass (Gastropoda)			1	0.4
53	unid. juvinile			17	7.6
54	Pisidium casertanum			24	10.7
55	egg mass (snail)	9	4.3		
56	egg mass (insect)	10	4.8		
TOTAL		208		225	

One fish (Cottidae) was collected in sample from Lake A.